REMARKS/ARGUMENTS

Claims 1, 2, 9, 10, 17-20, 27, 28, 35 and 36 were rejected as anticipated by Ray. Claims 3-8, 11-16, 21-26 and 29-34 were rejected over Ray in view of Schroedl et al.

Claims 1, 10, 19 and 28, the independent claims, have each been amended to specify that an estimate of rotor angle is made on the basis of rotor magnetic flux in the motor. Also claims 2 and 20 have been combined respectively with claims 1 and 19. Claims 1 and 19 further recite that estimated rotor angle is corrected on the basis of reactive power input to the motor; and this same feature is now being added to claims 10 and 28.

The present invention is directed to a system and method for indirectly determining the rotor angle in a drive control for an electric motor. The system of the present invention determines the rotor angle in an indirect way. As known to those of skill in the art, it is necessary to determine the position of the rotor of an electric motor such as a permanent magnet synchronous motor or a DC permanent magnet motor so as to properly commutate or switch the field. It is already known to use sensors disposed within the motor for example, Hall effect sensors, to determine the rotor position to enable proper commutation. However, the placement of sensors in the motor itself causes unnecessary complexity in the motor, increases the cost, requires additional components and electrical connections to the motor and decreases reliability. It is therefore desirable to eliminate any sensors in the motor for determining the rotor position and instead indirectly determine the rotor position by some other means.

As the Examiner has pointed out by citation to the Ray and Schroedl et al. references, it is also known to determine the rotor position without sensors in the motor by indirect means. However, the present invention goes a step further than merely determining or estimating the rotor angle in the motor. The present invention adds an additional step of correcting the estimated rotor angle on the basis of reactive power input to the motor.

With reference to Fig. 1 of the drawings of the present application, the present invention includes a rotor angle estimation block as shown in the lower left hand portion of Fig. 1. It is known to estimate the rotor angle. Applicant concedes that Ray and Schroedl et al. show means to estimate the rotor angle. However, Ray and Schroedl do not teach the additional step or means

to correct the estimation of the rotor angle via a rotor angle corrector as shown in Fig. 1. The rotor angle correction Del_Ang is added to the estimate of the rotor angle by a summing block as shown in Fig. 1 and this corrected rotor angle is then supplied into the control circuitry and, in particular, the PWM control to control the inverter bridge. There is no teaching or suggestion of this second step of correcting the estimated rotor angle in the prior art.

Fig. 2 shows how the rotor angle is estimated. Fig. 3 shows how the magnetic flux is estimated and Fig. 4 shows how the rotor angle correction Del_Ang is achieved.

Applicants submit that the Ray and Schroedl references do not teach or suggest the additional step of correcting the estimated angle.

In the Office Action in the parent case, the Examiner pointed to Ray at page Fig. 3 and col. 4, lines 37-46 for teaching the step of correcting the estimated rotor angle on the basis of reactive power input to the motor. However, Ray does not teach any step of correcting the estimated rotor angle. Instead, what Ray teaches is simply estimating rotor angle but Ray does not teach an additional step of correcting the rotor angle on the basis of reactive power input to the motor. At lines 37-46 at col. 4 of Ray, Ray teaches calculating the true rotor position from an angular difference $\Delta\theta$ between a predicted position and a reference position θ_r. However, this is merely a calculated estimate. Ray does not add a further step to refine that calculation. At line 41, Ray shows a formula $\theta_m = \theta_r + \Delta\theta$. However, this is not an additional correction to the rotor position. This is the calculation of the rotor position θ_m from the reference θ_r and the difference $\Delta\theta$. There is no additional step of correcting that calculation to refine the rotor position. Ray then proceeds to say that the next rotor position can be estimated using the known value of motor speed. He says a correction may be needed to be made to the motor speed. He does not indicate that a correction should be made to the estimate of the rotor angle. There is simply no teaching or suggestion in Ray of this concept. Similarly, in Schroedl et al., U.S. Patent No. 5,339,012, it is taught to calculate the rotor angle but there is no teaching or suggestion that a correction should be made to the calculated rotor angle to refine the estimate.

Applicants now refer to the article entitled "Sensorless Control of AC Machines at Low Speed and Standstill Based on the "INFORM" Method" by Manfred Schroedl. This reference teaches the application of a voltage test phasor V_s applied to the machine by the inverter to

determine a reactance, called the INFORM reactance which contains the desired information about the flux or rotor angular position. See page 270, right upper column. Schroedl continues at the top of page 271 stating that it is advantageous to obtain at least two measurements based on the applied test phasor V_s because then it is not necessary to know the INFORM reactance explicitly. By obtaining two or more measurements, the rotor position can be obtained without actually determining the reactance. However, Schroedl does not then refine the estimate obtained from the INFORM reactant measurements by performing a further correction on the estimated rotor angle.

This is clear from a review of Fig. 12 of Schroedl contained on page 276 of this paper where the block "INFORM and EMF - algorithm" is shown which applies the test voltage to the motor to allow the INFORM reactance based measurements. There is nothing in the signal processing block diagram of Schroedl which shows that an additional step of correcting the estimated rotor angle is made.

Accordingly, it is submitted that the references of record do not teach or suggest the two mentioned steps of the claims of the present application (estimating rotor angle and then correcting the rotor angle) and that accordingly, claims of the scope presented should be allowed.

Therefore, allowance of claims 1, 3-19, and 21-36 is requested.

Also submitted as new claims 37-44 are several dependent claims substantially containing subject matter that was found allowable in the parent application.

Each of independent claims 1, 10, 19 and 28 recites a step or function of "correcting the estimated rotor angle on the basis of reactive power input to the motor." This feature is illustrated by Figure 4, which shows processing of voltage and current data Vd, iq, Vq, id to determine an angle correction factor Del_Ang. Their new respective dependent claims 37, 39, 41 and 43 recite that the correcting step or function includes "calculating a first reactive power input value and a second reactive power input value, determining a relation between said first and second reactive power input values; and applying said relation to the rotor angle estimated in step (b) to obtain a corrected rotor angle." In the disclosed embodiment the "relation" is a difference. The Examiner cited Ray's Figure 3 and column 4, lines 37-46, which, however, fail to disclose or suggest such a feature. Allowance of claims 37, 39, 41 and 43 is therefore requested.

Regarding claims 38, 40, 42 and 44, each of these claims recites a step or function of correcting "phase errors caused by said non-ideal integration via a PLL circuit with phase compensation (F)." The Examiner cited col. 3, lines 45-51, and col. 4, lines 43-46 in Ray. The cited passages disclose neither correction of phase errors caused by non-ideal integration; nor a PLL circuit with phase compensation. The PLL circuit (Figure 2) is not mentioned in the Office Action. Allowance of claims 38, 40, 42 and 44 is therefore requested.

Each claim not discussed herein is allowable at least because of dependency from another allowable claim.

In view of the foregoing amendments and remarks, allowance of claims 1, 3-19 and 21-44 is respectfully requested.

I hereby certify that this correspondence is being deposited with the United States Postal Service with sufficient postage as First Class Mail in an envelope addressed to: Mail Stop Amendment, Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450, on March 22, 2005:

James A. Finder
Name of applicant, assignee or Registered Representative

Signature

March 22, 2005
Date of Signature

Respectfully submitted,

James A. Finder
Registration No.: 30,173
OSTROLENK, FABER, GERB & SOFFEN, LLP
1180 Avenue of the Americas
New York, New York 10036-8403
Telephone: (212) 382-0700

JAF:lf/jh